Probabilistic treatment of sub-reach-scale bed stress in long-term channel evolution models

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Abstract. Physically based models of drainage network evolution require expressions that relate the average rate of change of bed elevation to hydraulic parameters such as slope and discharge. Most such models rely on reach-scale averages of quantities such as shear stress, critical shear stress, and unit stream power. Yet variability is the hallmark of natural stream channels. For example, instantaneous near-bed velocity and pressure vary on spatial scales on ranging from that of the flow depth to that of individual roughness elements, and on time scales associated with turbulent structures such as bursts and sweeps. Because the relationship between shear and transport is nonlinear, this small-scale variability matters. This paper outlines a method for computing the reach-averaged rate of bed-elevation change using a statistical description of boundary shear stress. The approach is intended to bring us closer to being able to link flow physics, field and lab observations, and long-term behavior morphodynamics. Solutions are illustrated for cases of stable and steadily falling baselevel. In the case of a cohesive, fine-grained substrate, channels are predicted to respond to a baselevel drop by quasi-parallel retreat of a knickpoint; the shape of this feature and its evolution through time depend on a dimensionless threshold shear stress.